P-111: The Mechanical-Optical Properties of Wire-Grid Type Polarizer in Projection Display System

G.H.Ho, C.H.Chen, Y.C.Fang, H.S.Lin, C.R.Ou, T.Y.Chen

ITRI/Opto-Electronics & System Laboratory
Hsin-Chu, Taiwan

Abstract

In order to eliminate the thermal issues of the polymer based polarizer and thermal induce birefringence of bulky PBS, the wire-grid type polarizer is a promising optical component. However, as a part of the imaging optics, mechanical holding may affect the image qualities. In this article, two configurations for using wire-grid polarization are introduced. The image defects including astigmatism and distortion due to improper mechanical holding are evaluated.

1. Introduction

Contrast to the uniqueness and maturity of the design of TFT-LCD transmissive type optical engine, the design of LCoS reflective optical engine have much more variety. Due to the reflective nature of LCoS optical engine, certain optical designs separating the inward and outward light of LCoS panel have to be applied in front of the LCoS panel. Except for the off-axis design, a polarization beam splitter (PBS) is often used in on-axis design. However, PBS cause several problems; first, PBS has limited angle of incident which constrain the system f-number, second, a bulky PBS have strong thermal induce birefringence which result light leakage in dark state [1][2]. Recently, the Moxtek Technology unveils a wire-grid type polarizer (ProFlux™) which is claimed to have large angle of incident, high extinction ratio, and good thermal durability. To build the form birefringence [3], the ProFlux™ is manufactured by ultra-high precision photolithography.

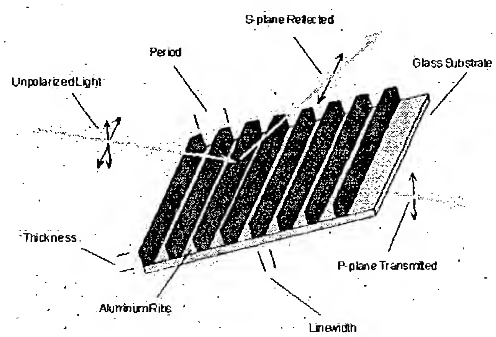

Fig.1 ProFlux™ polarizer (from Moxtek Technology website)

Fig.1 shows the scheme of the ProFlux™, which reflects the S-polarization and transmits the P-polarization. Furthermore, by cascading two ProFlux™s as in Fig.2, these two ProFlux™s can function as a PBS with large angle of incident and high contrast ratio. There are two kinds of configuration when using ProFlux™ as PBS. In the left Fig.2, S-polarization light transmits into the LCoS panel and going into projection lens with P-polarization (S-in-P-out). On the other hand, in the right of Fig.2 light go into LCoS panel with P-polarization and into the lens with S-polarization (P-in-S-out). Each configuration could result a particular image quality defect if mechanical holding for ProFlux 2 (the inclined plane) in either case is improper. In S-in-P-out case, finite thickness of ProFlux 2 may cause certain amount of astigmatism. In P-in-S-out case, little bending of ProFlux 2 result from improper holding may cause image distortion after passing through the projection lens.

 ISSN/0002-0966X/02/3301-0648-$1.00+.00

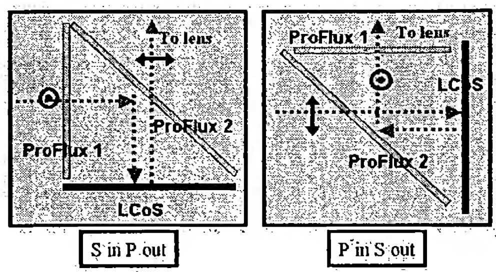

Fig.2 Two kinds of configuration of using ProFlux™ as PBS

In this article, sec.2 perform simulation surface bending of ProFlux due to improper holding, sec.3 perform image defects of the configurations discussed above, sec.4 conclusions.

2. Mechanical Holding Issues

When using two pieces of ProFlux as a PBS, the mechanical holding of the ProFlux 2 as shown in Fig. 2 has special concerns. A usual design of mechanical holding is a two-side holding as shown in Fig.3. When apply high temperature to the ProFlux, the thermal stress along the normal of the surface will causes the ProFlux polarizer bending. This will induce additional aberrations of the lens. We use a commercial software I-Deas™ to simulate the bending of the ProFlux polarizer under high temperature condition. With known geometrical, mechanical, and thermal parameters, the simulation result of bending of ProFlux polarizer is shown in Fig.3.

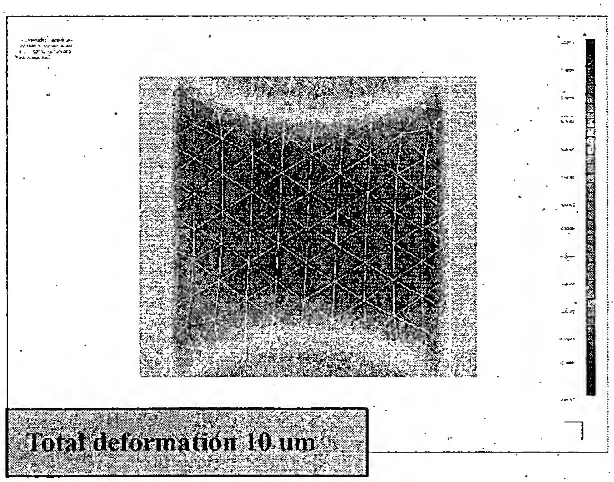

Fig.3 I-DEASsimulation result of a plate that is held two-sided and heated.

The bending profile can be applied to optical analysis software ASAP™ in order to simulate the aberration.

3. Image Qualities

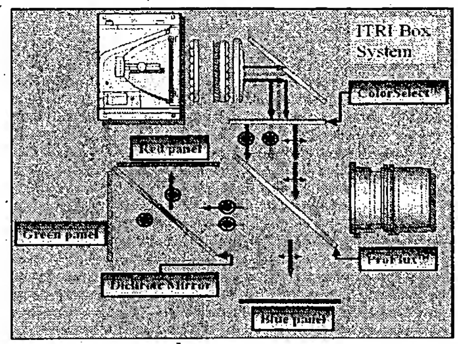

Fig.4 ITRI BOX system (patent pending)

In this section, we analyze the image defect due to using ProFlux as a part of image lens. The projection display system that applies tilted plates, as an example, is shown in Fig.4. The system 's targets are ultra portable, high brightness, and high contrast ratio. This system will also be announced in SID'02 with the name ITRI/BOX (patent pending).

3.2 Astigmatism

As in Fig.4, there are two parallel plates in the image optical path. When inserting two tilted plates with a finite thickness into the lens system, various kinds of aberration will occur. This tremendously increases the difficulty of lens design. A simple and clear simulation is performed with optical software ZEMAX™ as shown in Fig.5.

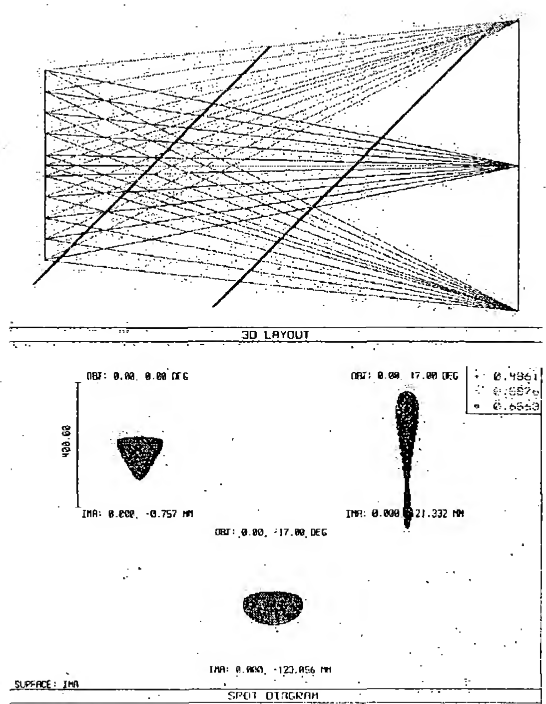

Fig.5 shows an ideal lens with inserting two parallel tilted plates. The below part is the spot diagram of different field angle

We place an ideal thin lens on the entrance pupil and set the field angle of ±17 degrees. There should be no aberration for every field angle. When inserting two plates with thickness of 1.6 mm, the spot diagram reveals serious aberration for different field angle. For on-axis image, there is an asymmetry between sagittal and tangential field. For the 17 degrees field, the asymmetry is even worse. Therefore the astigmatism is more obvious and shows up together with other kinds of off-axis aberration. The −17 degrees field shows much less astigmatism due to the rays are much more symmetry between sagittal and tangential. These aberrations become worse when increasing the thickness of the tilt plate.

A modified configuration is shown in Fig.6. The two tilted plates are arranged orthogonal to each other in order to compensate the induced aberration. The spot diagram in Fig.6 shows a great improvement of aberration for various field angles. For on axis field, there is almost only spherical aberration left. As for the off-axis field, the remanding aberration is mainly coma. The spot diagram of +17 and −17 degrees field is mirror symmetry to each other. This arrangement of two tilted plates can greatly reduce the difficulty of lens design for such a projection system.

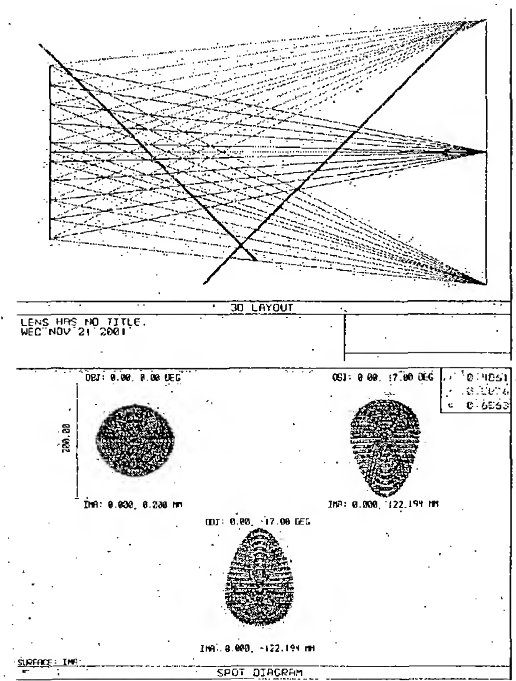

Fig.6 Modified configuration of two tilted plates and the spot disgram

3.2 Distortion

The simulation result in section 2 indicates that a finite thickness plate held from two sides and illuminated by high power lamp suffered from bending. For projection display system described in section 1, such plates exit in the imaging path of light. According to optical aberration theory, a bending plate in the imaging path will induce certain degree of field curvature. Besides the field curvature, there also comes along the combination of astigmatism and coma due to the anisotropic characteristic of the bending deformation. For LCoS projection display system, easily achieving high resolution is a merit. Therefore a high quality lens with high modulation transfer function (MTF) is necessary in order to perform high resolution images. According to the simulation via ASAP™ software, the occurring of aberration due

to a bending plate is significant and the more the amount of bending the worse the MTF of a lens.

There are two approaches to solve the bending problem of a finite thickness plate. The first is to change the thermal condition via extra cooling facility. By deliberately arranging fan with proper spinning speed in the side of the plate, the hot spot near the center part of the plate can be cooled down. And the thermal stress of the plate is reduced therefore the bending problem can be solved. However in a real projection display system especially for small and compact system, an extra spare space to arrange additional fan is usually not available.

Another way to solve the bending problem is to perform the one-side holding rather than conventional two-side holding. When a plate is illuminated by high power light, the temperature of illuminated area rises and a thermal stress is formed near the center part the plate. For a plate with two-side holding, since two sides of the plate are fixed there is no mechanical path to release the thermal stress. When applying one-side holding, there is only one side of a plate fixed. Therefore the thermal stress can be released from all the free side of a plate and bending problem is greatly reduced. According to I-Deas™ software simulation, the bending of the plate performing one-side holding is much less than that performing two-side holding under the same thermal condition. However since one-side holding only constrain one side of a plate, holding inaccuracy such as rotating, tilting should be aware.

4. Conclusions

The use of wire-grid type polarizer can theoretically enhances the contrast ratio and illumination f-number comparing to conventional PBS. However, in real projection display system thermal stress together with holding method can induce bending problem of the wire-grid type polarizer. When applying wire-grid type polarizer in the imaging path, certain level of additional aberration is induced. Through this article, we have analyzed the bending problem under simulated thermal condition and mechanical holding. And the induced aberrations have been studied. To solve this problem, ether using additional cooling facility or one-side holding method is a possible approach.

Reference

[1] W.T.Lee el. IDW`01, Section LAD2-3, pp. 1291~1294

[2] C.R.Ou el. SID`01, Section P-93, pp. 926~929

[3] Pochi Yeh, Optical Waves in Layered Media, a Wiley-Interscience Publication, chapter 6

[4] S.Arnold, SID`01, Section 52.3, pp. 1282~1285